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Whitepaper on Micronutrient in India

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1. Executive Summary

Micronutrient deficiencies in Indian soils raise major concerns for soil health, agricultural productivity, and food and nutritional security. These deficiencies diminish the nutritional quality of crops, contributing to widespread health issues such as anemia and stunted growth and, in turn, affecting human productivity and economic output. While macronutrient fertilizers, particularly urea, have driven impressive gains in crop yields and helped achieve self-sufficiency in staple grains like wheat and rice, their imbalanced application has contributed to soil degradation and a widespread depletion of essential micronutrients. The resulting decline in soil fertility threatens long-term agricultural productivity and compromises the resilience of India's cropping systems. Addressing these challenges is vital to secure India's food supply, enhance farmers' incomes, and ensure sustainable agricultural practices.

Several studies have highlighted the importance of micronutrients, such as zinc, boron, iron, manganese, and copper, in boosting crop yields, by 15-25%, reducing production costs, and improving produce quality, thereby positively impacting farmers' earnings. However, a study by the Indian Council of Agricultural Research (ICAR) has identified significant deficiencies in these micronutrients across Indian soils - zinc deficiency in 36.50% soils, boron deficiency in 23.20% and iron deficiency in 12.80% highlighting major areas of concern. Despite these concerning figures, the adoption of micronutrient fertilizer has been limited to a few crops and regions. The nutrient imbalance is further intensified by intensive cropping practices and inadequate application of micronutrients.

Policy makers have taken cognizance of India's micronutrient crisis and implemented various initiatives for addressing micronutrient deficiencies in the soils. These initiatives include subsidy for micronutrient fortified fertilizers, extension services through State Agriculture Universities, Krishi Vigyan Kendras, and research institutions, and research support to promote micronutrient usage in the country.

Nevertheless, the micronutrient adoption encounters substantial challenges, including including an emphasis on NPK fertilizers, limited awareness among farmers on cost-effectiveness of micronutrients, high costs of fortified fertilizers and differential treatment for micronutrients under GST regime and basic custom duty. Additionally, the cost of raw material prices of zinc and boron, required for fertilizer fortification, have increased considerably over past fifteen years complicating the availability and affordability of micronutrients in the country.

The Enabling the Business of Agriculture 2019 report from the World Bank acknowledges India's favorable fertilizer regulation quality but points out challenges in registering new fertilizers products. These hurdles include lengthy and complicated process involving multi-location trials and associated high costs. Globally, several countries have taken policy initiatives to promote the usage of micronutrients. While some countries have initiatives specifically targeted at micronutrients like Turkey, Brazil, and China, others have overarching programs under which micronutrient usage is promoted (Malaysia, Indonesia). Many countries have simplified import of micronutrients by offering import tax exemptions and duty-free imports.

Addressing these challenges is vital for fostering innovation and improving the availability of micronutrient fertilizers for Indian farmers. Thus, an urgent reassessment of the current policy framework is needed to enhance both the supply and demand of micronutrient fertilizers in India. Industry leaders have highlighted several key reforms and interventions to promote the use of micronutrients in the country:

Ease of micronutrient product registrations: Simplifying the product registrations, within the necessary regulatory framework for micronutrients can encourage fertilizer companies to bring innovative products to the market. This would also translate to lower prices for farmers as costs associated with cumbersome registration process are not passed on to farmers.

Creating a unified application system for product registration and licensing for fertilizers: A unified platform for fertilizer product registration and licensing, that can be accessed by the Central Government and all State Governments can help in reducing compliance costs and timelines to introduce innovative products to the farmers.

Periodic review of fortified fertilizers subsidy under NBS scheme: A committee of experts can be appointed to review the subsidy provided for fortification with boron and zinc to adjust with raw material costs and keeping fortified fertilizers affordable and accessible to the farmers.

International year of micronutrients: An International Year of Micronutrients can highlight the role of micronutrients in agriculture and public health, fostering global efforts to address deficiencies and support long-term productivity.

Review of GST and import duty structure: Aligning GST rates for micronutrients can create a favorable market environment for fortified fertilizer products and support micronutrient adoption. The end- use quantity of raw material may be monitored based on fertilizer distribution through point-of-sale machines and innovative digital technologies and the GST exemptions may be considered accordingly.

Digital crop booking and customized fertilizer recommendation: Agri-tech, including artificial intelligence and GIS tools, along with initiatives like Krishi Mapper and Agri Stack, can optimize soil health by creating micronutrient maps and providing tailored fertilizer recommendations, enhancing crop productivity, and reducing environmental impact cause by fertilizer over-usage.

Strengthening soil testing labs for micronutrient testing capabilities: Partnering with private players and the fertilizer industry could enhance the scheme's effectiveness by improving the accuracy, efficiency, and scalability of soil testing through public-private partnerships.

2. Micronutrient Crisis in India

India, with large area under agriculture and rising population, is at crucial juncture to adopt technological advancements in agriculture to bolster agricultural sustainability and ensuring food security. However, underneath the milestones achieved in agriculture and the bumper harvests enjoyed by India, there lies a calm catastrophe. While from 30,000 feet, one can visualize filled granaries as a reflection of several progressive interventions implemented by the Government to enhance production and agricultural productivity, a microscopic analysis reveals an often overlooked yet fundamental issue – the depleting essential nutrients in the Indian soil and the deterioration of soil health. This poses serious repercussions including low productivity, poor nutritional value in food, and heightened vulnerability to biotic and abiotic stresses.

Soil micronutrients play vital role in the growth, productivity, and nutritional composition of the crops, consequently affecting the nutritional well-being of humans and animals that depend on those crops[1]. The silent epidemic of micronutrient deficiencies has been associated with adverse impact on learning, lower Intelligence quotient, motor skills, and weakened immune system function among children and potentially leading to lasting effects into adulthood[2]. A survey undertaken by the Ministry of Health and Family Welfare, Government of India indicated that 32% of preschoolers (ages 1-4 year), 17% of school-aged children (ages 5-9 year), and 31% female and 12% male adolescents (ages 10-19 year) were suffering from iron deficiency, whereas 19% of preschoolers, 17% of school-aged children and 32% of adolescents were found to have varying degrees of zinc deficiency[3].

While micronutrient deficiency in soils is a global issue, India's situation is more concerning due to its wide-spread prevalence and severity of micronutrient deficiency[4]. This issue is potentially linked with intensive crop cultivation, reduced application of organic manures, and imbalanced fertilizer application. Consequently, large tracts of agricultural soils are reported to be deficient of essential micronutrients such as boron (B), zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), and molybdenum (Mo).

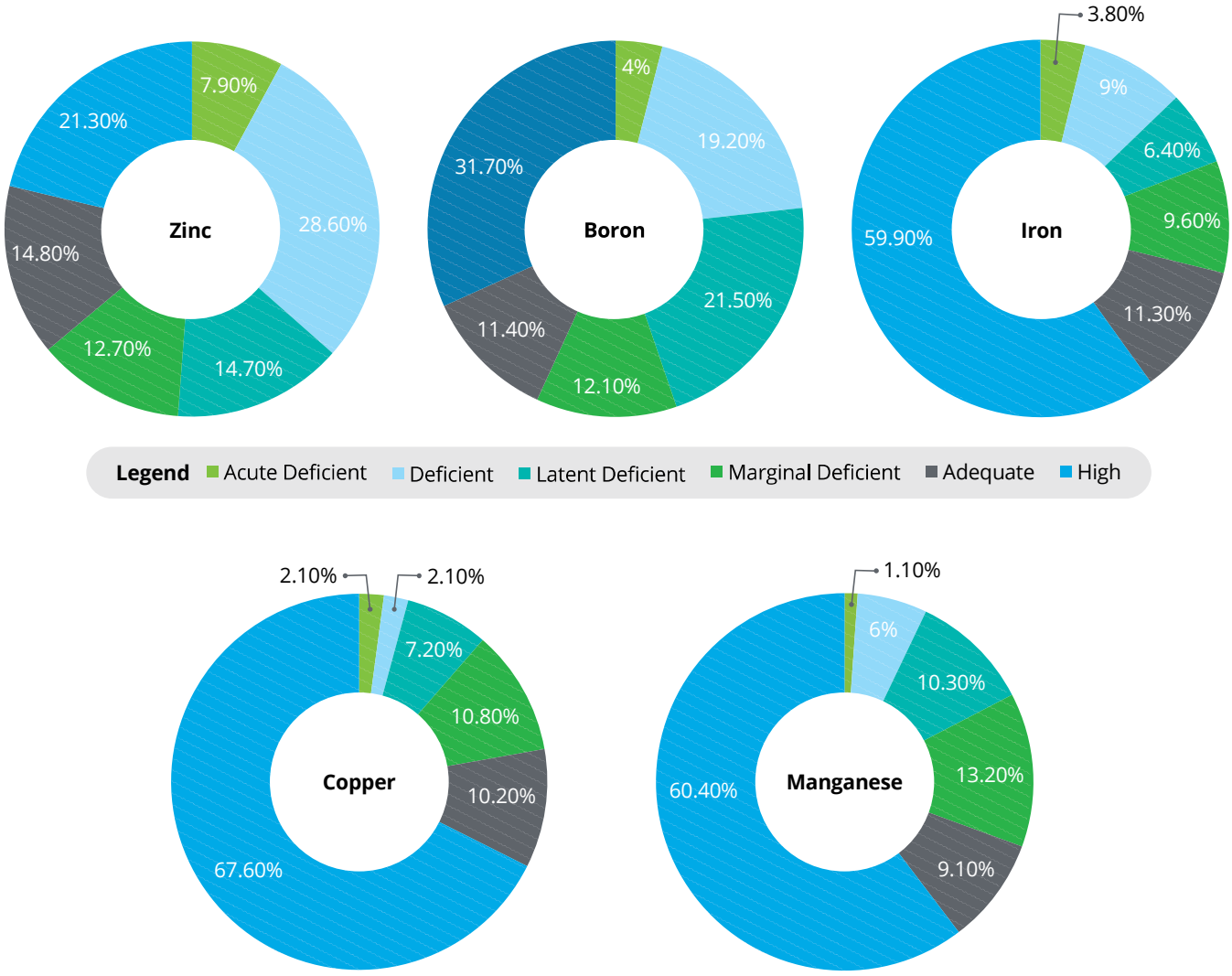
2.1 The Crisis

Since advent of green revolution, fertilizer application in India has been marked with focus on macronutrient fertilizers. Farmers have often overlooked the importance of micronutrients in Integrated Plant Nutrient Management (IPNM) as a holistic approach to optimizing soil fertility and crop productivity. As per Fertiliser

[1] Morton CM et al. (2023) Soil micronutrients linked to human health in India. Sci Rep. 2023 Aug 21;13(1):13591
[2] Swaminathan S, Edward BS, Kurpad AV. (2013) Micronutrient deficiency and cognitive and physical performance in Indian children. Eur. J. Clin. Nutr. 2013;67(5):467–474.
[3] Ministry of Health and Family Welfare, GoI, United Nations Children's Fund and Population Council. Comprehensive national nutrition survey (CNNS) national report. New Delhi: MoHFW, GoI, UNICEF and Population Council; 2019.
[4] https://www.downtoearth.org.in/blog/food/tackling-hidden-hunger-strategies-to-combat-micronutrient-deficiencies-0492#:~:text=While%20hidden%20hunger%20remains%20a,%2C%20copper%2C%20boron%20and%20molybdenum.

Association of India (FAI), the Nitrogen-Phosphorus-Potassium (N-P-K) ratio in Indian agricultural soil is very high (10.9:4.9:1 in *Kharif* 2023 season). This has resulted in the degradation of soil health and imbalance in soil nutrients over the years. According to a study conducted by Indian Council of Agricultural Research (ICAR), the micronutrient deficiencies (acute deficient + deficient) in Indian soil are at 36.5% for zinc, 23.2% for boron, 12.8% for iron, 4.2% for manganese, and 7.1% for copper[5]. The extent of deficiency / sufficiency of micronutrients is provided in Figure 1.

Figure 1: Extent of Deficiency of Micronutrients in Indian Soil



Source: Shukla A.K et al. (2021). Deficiency of phyto-available suphur, zinc, boron, iron, copper and managense in soils of India.

[5] Source: Shukla A.K et al. (2021). Deficiency of phyto-available suphur, zinc, boron, iron, copper and managense in soils of India.

The skewed use of macronutrient fertilizers and low micronutrients application can be attributed to a combination of factors including higher cost of micronutrient-based fertilizers, limited awareness among farmers and soil testing facilities. Some of the key reasons for the current micronutrient crisis are:

Policy Emphasis on N-P-K Fertilizers: Since the Green Revolution, the government has focused on enhancing self-sufficiency in food grains, primarily by promoting N-P-K fertilizers due to their direct and visible impact on crop productivity. This approach has yielded significant dividends, making India self-reliant in food grains and leading agriculture economy in the world. However, the emphasis on N-P-K fertilizers and the corresponding budgetary allocations have limited the accessibility and affordability of micronutrients in the country.

Farmers' Knowledge: There is limited awareness among many farmers regarding the crucial role micronutrients play in overall crop production and their proper application. This has led to underutilization of micronutrient fertilizers.

Soil Testing Facilities: While the Government has taken various steps in improving the soil testing infrastructure and mobile testing units in the country, however, the requirement for soil testing is far exceeding the capacity of soil testing labs in the country leading to delays in generating soil test reports. Due to this, farmers often apply generic recommendation of fertilizer rather than crop and location specific nutrient applications. Limited facilities for micronutrient testing have further compounded the problem.

Cost Barrier: The micronutrient-based fertilizers are costlier compared to NPK fertilizers. This price difference renders micronutrient fertilizers less accessible to small and marginal farmers, who typically prefer low-cost macronutrient fertilizers over costlier fortified or customized formulations.

Need for Enhanced Support for Micronutrient Fertilizers: While the fertilizer industry, at large, receives consistent support from the Government through research and policy interventions, there is need for focused support for the micronutrient fertilizers sub-sector to address widespread deficiency in soils and promote affordability of micronutrient fertilizers.

Addressing these critical issues requires a multifaceted approach including awareness creation among farmers, revisiting agricultural policies for promoting micronutrient application, reducing the cost anomaly through focused subsidies and rationalizing tax regime, promoting investments in research and development, and improving access to reliable soil testing services.

2.2. Purpose of the Whitepaper

The Global Micronutrient Summit 1.0 (GMS 1.0) was organized in September 2019 to deliberate the role of micronutrient application in soil and its impact on plant, animal and human health. The Summit also focused on innovations to improve use efficiency of micronutrients, policy reforms to promote their adoption in Indian agriculture and streamlining registration process. Subsequently, GMS 2.0 was organized in October 2023 to explore the role of micronutrients in crops production, soil health management and impact of micronutrient deficiency on human and animal health. It was attended by more than 200 participants from India as well as other countries including Policy makers, academia, research scientists, leader from fertilizer companies, and various industry stakeholders.

During the summit, participants deliberated and emphasized the need for amendments in agriculture policy to promote the use of micronutrients in agriculture throughout the country. Stakeholders outlined various challenges, which are detailed below:

Registration and approval: Micronutrient fertilizers must undergo registration and approval processes with regulatory authorities such as the Ministry of Agriculture & Farmers' Welfare, Government of India. During stakeholder consultation, industry leaders expressed concerns about lengthy approval timelines for new product registration including need for multilocation trials, or licensing requirement in each state which delays the commercialization of new fertilizer product.

Differential taxation and custom duty on micronutrient fertilizers and bulk fertilizers: Industry leaders highlighted that micronutrient fortified fertilizers attracted higher Goods and Sales Tax (GST) rate of 12-18%. Rationalizing GST rates on micronutrient-based fertilizers would help in making micronutrients more affordable to farmers.

Nutrient based subsidy: The increasing production costs of fortified fertilizers, coupled with regulated MRP, pose serious challenge for affordability of micronutrient-based fertilizers. In addition, non-inclusion of various fortified fertilizers and customized fertilizers, specified in the Fertilizer Control Order (FCO) 1985, remains another barrier to promoting different types of micronutrient fertilizers. The Government initiative on NBS had been instrumental in promoting micronutrient fortified fertilizers, however the prices of raw material have increased over the years while the subsidy for zinc and boron has remained unchanged since 2010-11.

Price regulations: The industry players highlighted that maximum retail price (MRP) regulations require manufacturers to charge only up to 10 per cent higher than notified MRP, despite higher cost of production, complex manufacturing processes, regulatory compliance costs, and additional marketing efforts required[6]. Further, the raw materials prices for micronutrients production may fluctuate which are not considered for arriving at the notified MRP. Price regulations can potentially discourage innovation and investment in R&D, limiting the availability of advanced micronutrient formulations that could benefit agricultural productivity.

Following the consultations during GMS 2.0, the International Zinc Association (IZA) highlighted the significance of a policy assessment addressing critical issues of the micronutrient fertilizer sector and promote their use for Viksit Krishi to achieve Viksit Bharat. This paper embarks on exploration of the multifaceted dimensions of the micronutrient crisis in Indian agriculture, shedding light on its causes, consequences, and potential solutions.

[6] https://www.business-standard.com/industry/agriculture/addressing-zinc-shortage-to-boost-agricultural-quality-soil-health-124041000840_1.html

3. Shaping the Future of Agriculture – Role of Micronutrients

India's agricultural sector is grappling with issues stemming from imbalanced used of fertilizers and depletion of micronutrients in soil strata. Over time, the failure to replenish these essential elements has resulted in lower availability of the micronutrient necessary for crop growth and yield improvement. Factors contributing to this issue include intensive cropping practices, a predominant reliance on N-P-K fertilizers particularly urea, decreased application of organic manure, limited crop rotation with legume crops, and cultivation in soils with reduced micronutrient reserves, all of which have negatively impacted crop production and farm incomes.

It is critical for all the stakeholders to take corrective measures and mitigate potential impacts on crop yields, farmer incomes, and potentially on national food security, as well as public health, before the time runs out. Solutions should prioritize integrated nutrient management and technological advancements to enhance resilience against potential threats. The policy framework must be revisited to implement interventions in time-bound manner and ensuring a proactive approach to safeguarding food security of the nation and economic stability of farmers. Promoting micronutrients application in agriculture can not only improve crop yields but also increase quality of the produce[7] and resulting in higher economic value for farmers' produce.

[7] Shukla A.K et al. (2019). Importance of Micronutrients in Indian Agriculture, Better Crops – South Asia.

Micronutrient fertilizers can significantly contribute to achieving several Sustainable Development Goals (SDGs) by enhancing crop health, nutrition, and overall agricultural practices.

Goal 2: Zero Hunger

- **Increased Crop Yields:** Micronutrients are essential for robust plant growth. By addressing deficiencies, micronutrient fertilizers can greatly increase crop yields, improving food security in regions facing hunger.
- **Improved Nutritional Quality:** Micronutrients are vital for human health. Crops grown with micronutrient-fortified fertilizers can have higher levels of essential vitamins and minerals, promoting better nutrition for consumers.

Goal 3: Good Health and Well-being

- **Combating Hidden Hunger:** Micronutrient deficiencies, also known as hidden hunger, are a significant global health concern. Micronutrient fertilizers can help address these deficiencies by ensuring crops contain adequate levels of essential micronutrients like zinc and iron.

Goal 12: Responsible Consumption and Production

- **Improved Nutrient Use Efficiency:** By specifically addressing micronutrient deficiencies, micronutrient fertilizers can help farmers use fertilizers more efficiently. This reduces overall fertilizer application and minimizes potential environmental impacts from excess nutrients.
- **Enhanced Soil Health:** Micronutrients play a crucial role in maintaining healthy soil ecosystems. Their proper application can contribute to improved soil fertility and long-term agricultural sustainability.

Goal 15: Life on Land

- **Improved crop yields and resilience:** The increased food security due to higher yields from the usage of micronutrients reduces the pressure on natural land to cultivate more food.
- **Reduced need for land expansion:** With improved crop yields on existing agricultural land, there's less incentive to clear or convert natural habitats for additional farmland. This helps conserve biodiversity and ecosystem services.

3.1 Impact on Farmer's Income

Micronutrient deficiencies directly or indirectly impact crop production, yield, and unit cost of cultivation and ultimately farmers' earnings. The soils have been depleted of vital mineral elements as a consequence of decades of intensive farming, resulting in diminishing response to higher doses of fertilizers. Without prompt action, the micronutrient deficiencies may severely impact crop production, farmer livelihoods, and potentially trigger a food security crisis for a country where about 65 percent of the population is engaged in agriculture and allied activities directly.

3.1.1 Impact on Crop Yield

India's shift toward increased ethanol production from food grains, particularly maize and rice, reflects a broader global trend aimed at reducing reliance on fossil fuels and promoting renewable energy sources. India is focusing on grains to meet the goal of blending 20% ethanol with petrol by 2025-26. This year, the share of India's ethanol derived from food grains like maize and rice increased from 37.4% to 51%[8]. As food grains are redirected for ethanol production, the country must ramp up grain production to feed its growing population.

Various research and studies have demonstrated substantial improvements in crop yield with

[8] https://www.hindustantimes.com/business/indias-ethanol-production-gradually-shifts-from-sugar-to-maize-and-rice-101719462155575.html#:~:text=India%20achieved%20higher%20production%20of,who%20had%20access%20to%20the

micronutrient application. For instance, micronutrients applications are associated with increase in plant height, number of spikelets, and grain mass in crops like paddy and wheat. The studies also established that boron application could improve the overall quality of output, reduced panicle sterility and increased the milling return and head rice recovery[9]. However, the true potential of micronutrients has not been realized due to limited application by farmers. Studies have established that micronutrient applications increase wheat yield by 10-25%[10]. Another study mentioned that boron application in wheat increases the 1000 grain weight, number of grains per spike[11].

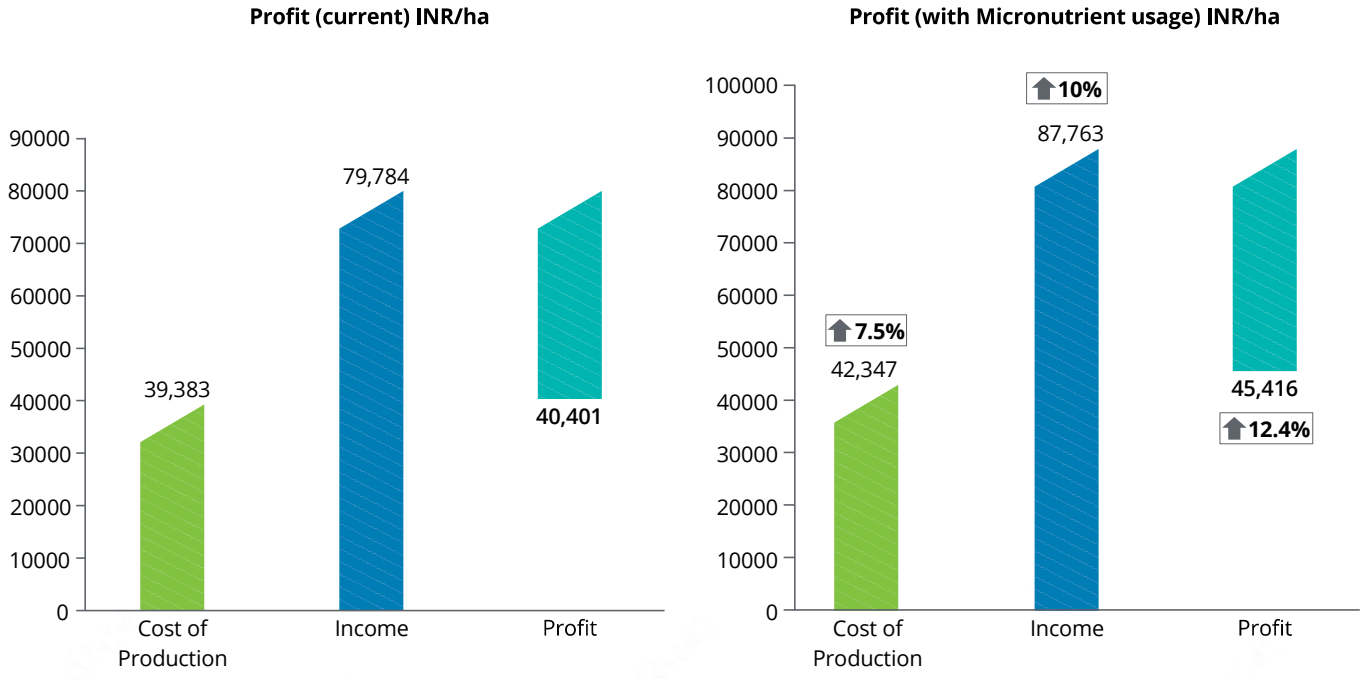
Figure 2: Statement of the Standing Committee on Chemicals & Fertilizers, Lok Sabha

> In India, there is a little scope of bringing in more area under cultivation; therefore, growth in food grain production has to come largely through productivity enhancement. However, fertilizer consumption in India is imbalanced, and Urea accounts for more than 82% of the nitrogenous fertilizers applied to majority of the crops. Resultantly, the Nitrogen, Phosphorus and Potassium (NPK) consumption ratio has widened from 4:3.2:1 in 2009-10 to 7:2.8:1 in 2019-20.
>
> **Standing Committee on Chemicals & Fertilizers, Seventeenth Lok Sabha, 2022-23**

Use Case: A comparative study on cost economics of micronutrient usage by wheat farmers:

An assessment of potential income and profit growth for wheat farmers on account of micronutrient application suggests that with moderate increase of 7.5% in production costs, could increase 10% yield and result in a corresponding 10% rise in gross income for the from in wheat. Consequently, this would translate into a ~12% increment in net income. (Figure 7).

Figure 3: Comparison of Impact of Micronutrient Usage on Farmer's Profit



Source: Ministry of Agriculture & Farmers' Welfare; Deloitte Analysis

[9] Pratibha Singh et al. 2020. Boron Fertilization and Crop Production in India: A Review, Indian Journal of Agricultural Sciences 90(1): 9-16, January 2020
[10] Francess Sia Saquee et al. 2023. The Efficacy of Micronutrient Fertilizers on the Yield Formulation and Quality of Wheat Grains
[11] Ghatak R, Jana P K, Sounda, G, Ghosh, R K and Bandyopadhyay P. 2006. Effect of boron on yield, concentration and uptake of N, P and K by wheat grown in farmer's field on red and laterite soils of Purulia, West Bengal. Indian Agriculturist 50: 15-77

3.1.2 Impact on Crop Quality

Micronutrient deficiencies can adversely affect produce quality parameters such as the size, shape, visual appearance, and nutritional value. Crops may not exhibit their potential quality parameters and develop less appealing produce, reduced nutritional value, and a shorter shelf life without balanced use of these vital micronutrients. For farmers engaged in horticultural crop production, maintaining the quality is an important aspect of agronomic practices as it directly influences customer choice, marketability and fair value of the produce and long-term sustainability of orchards[12]. The imbalanced micronutrients application may adversely impact the quality parameters and significantly reduce the price realization by farmers.

Enhanced Appearance and Size

Micronutrients are vital in various plant physiological processes that influence appearance and size. For instance, boron is crucial for growth of cell wall resulting in firmer fruits with superior shape. Zinc has been associated with proper cell division, resulting in larger fruits and vegetables[13].

Improved Color and Shelf Life

Micronutrients can act as a catalyst for biosynthesis of pigments like chlorophyll (green) and carotenoids (red, orange, yellow)[14]. Lack of micronutrient application may lead to necrosis of tissues and improper color development, making crops less appealing to consumers. Additionally, few micronutrients play role in delaying ripening in fruits by inhibiting ethylene activity. This can result in better shelf life of horticulture produce.

Increased Nutritional Value

Crops grown under micronutrient deficiency may lead to lower levels of vitamins and minerals like iron, zinc, and iodine. Crops grown with balanced use of micronutrient fertilizers can lead to biofortification of crops, and can help combat hidden hunger (micronutrient deficiencies). The application of Zn-containing fertilizers is a quick and effective approach to biofortifying cereal grains with Zn, thus being an excellent complementary tool to the breeding strategy for successful biofortification of cereals with Zn[15]. Increasing evidence is available from field trials showing that soil and/or foliar application of Zn fertilizers improves grain Zn concentration up to 2- or 3-fold.

Reduced Susceptibility to Defects

Micronutrient deficiencies can also manifest as physical defects in crops, for instance, a boron deficiency can cause fruits and vegetables to become misshapen. This issue can be resolved through the proper application of micronutrients to produce blemish-free, high-quality crops.

[12] https://www.sciencedirect.com/science/article/pii/S0304423823006805#:~:text=Micronutrients%20crucially%20affect%20the%20growth,and%20address%20global%20malnutrition%20concerns.
[13] https://agrilifeextension.tamu.edu/library/gardening/essential-nutrients-for-plants/
[14] Eleonora Di Salvo et al. (2023). Natural Pigments Production and Their Application in Food, Health and Other Industries.
[15] Ismail Cakmak, (2009). Enrichment of fertilizers with zinc: An excellent investment for humanity and crop production in India, Journal of Trace Elements in Medicine and Biology, Volume 23, Issue 4, 281-289.

3.1.3 Impact on Production Costs

Micronutrient deficiencies pose significant threat to the income stability of farmers in India. These long-standing deficiencies have resulted into declining responsiveness to fertilizer application and decreased nutrient use efficiency. As a result, farmers are applying higher doses of fertilizers more frequently, which increases the susceptibility of crops to pests and diseases, potentially increase their pest control efforts. Both the factors contribute to higher production costs for farmers.

Improved Nutrient Use Efficiency

Traditional NPK fertilizers often have a low uptake rate by plants, which means that a substantial portion gets wasted or leached into the soil. Adding micronutrients together with Nitrogen to non-responsive soils increases yields by increasing Nitrogen uptake in a variety of soil conditions[16]. Incorporating micronutrients into fertilizers can foster more sustainable and productive agricultural practices and enabling farmers to reduce the overall fertilizer doses without compromising yields and savings on fertilizer cost.

Reduced Risk of Re-application

Micronutrient deficiencies can sometimes lead to stunted plant growth and the crop may exhibit symptoms like chlorosis, poor root development, and reduced yields during the growth stage. This often leads farmers to apply corrective doses of fertilizers later during the growth period, which can increase costs and affect crop quality. By addressing deficiencies early on with micronutrient fertilizers, farmers can avoid the need for additional applications[17], saving time and resources.

Improved Disease Resistance

Optimal levels of micronutrients can fortify plant cell walls and improve overall plant health. When NPK fertilizers are combined with micronutrients, plants become more resistant to a number of diseases. Research indicates that 30% and 60% of the reduction in disease spread in crops are linked to the application of copper, zinc, manganese, calcium, and magnesium[18]. These nutrients not only directly inhibit pathogen growth but also aid plants in developing resistance to future disease outbreaks.

3.2 Impact on Food and Nutritional Security

Micronutrient deficiencies among humans are an escalating global health issue, impacting over two billion people. These deficiencies can lead to serious consequences including death, disease, and challenges associated with learning, development, and immunity. Zinc deficiency is a particularly concerning; studies estimate that one-third of the world's population suffers from zinc deficiency, with rates ranging from 4% to 73% in different countries[19]. It results in more than 0.5million deaths per year in infants and children below 5 years of age worldwide[20]. Various models suggest that rising carbon dioxide levels could lead to an additional 175 million people becoming zinc deficient by 2050[21]. Various studies have indicated a connection between soil mineral availability and human health in India, highlighting the potential benefits of agronomic fortification. With the global population projected to grow significantly by 2050, the Food and Agriculture Organization (FAO) estimates that nearly 50% more agricultural production will be required to feed the growing population[22]. Fortifying commonly used

[16] https://www.fertilizer.org/news/micronutrients-roles-in-improving-crop-yields-and-the-effectiveness-of-nanoscale-formulations/#:~:text=Certain%20micronutrients%2C%20such%20as%20B,preserving%20vegetables%20and%20tuber%20crops.
[17] Alloway, B. J. (2013). Functional roles of micronutrients for sustainable agriculture. Applied and Environmental Soil Science, 2013, 15.
[18] https://www.fertilizer.org/news/micronutrients-roles-in-improving-crop-yields-and-the-effectiveness-of-nanoscale-formulations/#:~:text=Certain%20micronutrients%2C%20such%20as%20B,preserving%20vegetables%20and%20tuber%20crops.
[19] Pratibha Singh et al. (2020) Boron Fertilization and Crop Production in India: A Review, The Indian Journal of Agricultural Sciences 90(1): 9-16
[20] https://journals.sagepub.com/doi/pdf/10.1177/2333794X211050316
[21] Claire M Morton et al. (2023) Soil micronutrients linked to human health in India.
[22] IZA publication - All for a good harvest: Addressing micronutrient deficiencies.

fertilizers with zinc and foliar application of zinc fertilizers are seen as effective strategies to address zinc deficiency in India. The use of micronutrient fertilizers can positively influence food and nutritional security in several ways, including:

01

Improved Food Security:

- Increase in crop yield by micronutrients is crucial for meeting the food demands of a growing population and reducing hunger.
- By enhancing plant health and disease resistance, micronutrients can help reduce crop losses from pests and diseases, leading to a more stable food supply.

02

Enhanced Nutritional Security:

- The biofortification of micronutrients enriches crops with essential vitamins and minerals. This helps combat hidden hunger, a major public health concern globally.
- Better crop yields and quality due to micronutrients can encourage a wider variety of crops to be grown and consumed, ensuring a balanced intake of essential nutrients.

Increased food availability helps address hunger and malnutrition, especially in vulnerable populations.

Reduced Hunger

Biofortified crops provide essential micronutrients, contributing to better overall health and addressing dietary deficiencies.

Improved Public Health

Higher crop yields and improved food quality can lead to higher incomes for farmers, contributing to better livelihoods and poverty reduction.

Enhanced Livelihoods

Use Case: Pulses Estimated Requirement vs Production by 2047 in India:

According to the Dietary Guidelines of National Institute of Nutrition, the per capita Recommended Dietary Allowances (RDA) of pulses is 80 g/day[23] while the current consumption is only about 40 g/day. With India's population expected to reach 1.70 billion by 2047[24], the total demand for pulses is estimated to be 49 million tonnes, while production is projected to be 50 million tonnes (Figure 8). The production would only suffice to meet the RDA requirement and any drop in output due to unforeseen circumstances could lead to severe shortfall in pulses availability. Pulses require the micronutrients boron and zinc to flourish[25]. Zinc is required for enzyme activation, photosynthesis, and protein synthesis, while boron is important for cell wall formation, cell division, and sugar transport. Seed germination, root growth, plant growth, yield, and quality of pulses crops are all improved by an adequate and well-balanced application of boron and zinc. Therefore, it is essential for sustainable agriculture and food security to gain insight into the function of boron and zinc in the cultivation of pulses crops.

[23] Dietary Guidelines for Indians – A Manual (2011), National Institute of Nutrition, Indian Council of Medical Research.
[24] https://www.thehindu.com/incoming/indias-urban-population-would-require-230-million-housing-units-by-2047/article67238401.ec
[25] https://www.thepharmajournal.com/archives/2023/vol12issue7/PartAO/12-7-77-817.pdf

Figure 4: Pulses Estimated Requirement vs Production in India in 2047

Source: Deloitte Analysis

3.3 Impact on Imports

Despite commendable progress made in agriculture over last few decades, India is still import dependent for certain agri- commodities particularly for oilseeds and pulses. During FY 2023, India imported food items worth approximately $37 billion and has increased by 51% during last 5 years[26]. During 2022-23, India imported 16.47 million tonnes[27] edible oil out of which RDB Palmolein and Crude Palm Oil accounted ~59% and by Soybean oil accounted for 22%. Over-reliance on imports makes India vulnerable to external factors like global price fluctuations, geo-political situations, climate risks and global supply chain disruptions. Apart from increasing food security risks, it causes the following issues.

a) **Vulnerability to Price Shocks:** India's reliance on foreign markets exposes it to price fluctuations in those markets. This can lead to inflation and impact food security, especially for poorer populations.

b) **Foreign Exchange Outflow:** India spends a significant amount of foreign exchange on importing pulses and oilseeds. This is negatively impacting India's foreign exchange by $20.56 billion in 2022-23 alone[28].

To achieve self-reliance in edible oils, Government of India has approved National Mission on Edible Oils-Oilseeds (NMEO-Oilseeds) for 2024-25 to 2030-31 with an outlay of Rs 10,103 crore and to increase oilseed production from 39.67 million tonnes in 2022-23 to 69.7 million tonnes by 2030-31.

Soybean is important oilseed crop in India, with annual production of 13.06 million tons. However, India is lagging in soybean yield among leading soybean producing countries.

Countries	Productivity (Kg/ Ha.)
Brazil	2951
United States	3330
India	1069
Global	2563

Source: FAO 2022

The low level of productivity in soybean can be linked to various factors, including the limited application of essential micronutrients like zinc, iron, boron, and manganese, which are crucial for the healthy growth of soybean crops and increased yields. A study carried out at the JNKVV research farm during 2014-15 found that applying boron enhanced soybean yield by 9-12%[29].

[26] https://fas.usda.gov/data/opportunities-us-agricultural-products-india#:~:text=In%20FY%202023%2C%20India%20imported,of%20agricultural%20and%20related%20products.
[27] https://seaofindia.com/import-of-vegetable-oils-nov-21-apr-22-up-by-4-but-apr-22-import-down-by-13/
[28] https://www.livemint.com/news/india/centre-plans-stringent-policy-measures-for-reducing-pulses-and-edible-oil-imports-in-its-100-day-agenda-11718014555179.html
[29] https://epubs.icar.org.in/index.php/AAR/article/download/127515/47756/332457

Case: India's Palm Oil Story

Palm oil is the world's most consumed edible oil, with a global consumption nearing 80 million metric tons (MMT)[30]. It's a key ingredient in processed foods, especially in developing countries. Indonesia & Malaysia account for approximately 83% of the global production of palm oil wherein more than 75% of the production is being exported to international markets. India, the largest importer of edible oils, depends on imports for around 55% of its consumption. Between 2013 and 2023, India's edible oil consumption grew by nearly 3%, and with rising urbanization, the growth rate is expected to reach 3.5%. Palm oil consumption, currently at 9 MMT, makes up 40% of India's total edible oil consumption, and India represents about 20% of global palm oil imports[31]. To reduce this import dependency, India is promoting domestic oil palm cultivation through initiatives like the National Mission on Edible Oils – Oil Palm (NMEO-OP). The mission aims to boost production, especially in states like Andhra Pradesh, Telangana, Karnataka, and the northeastern region alone holds the potential for about 35% of national crude oil production[32].

Studies have established the role of boron in enhancing oil palm productivity. Boron deficiency can lead to poor physical growth of oil palm, causing deformities in leaves and poor fruit set[33]. Global leaders in oil palm production, Malaysia, and Indonesia, owe their success to efficient nutrient management, particularly boron application. Their success in oil production is certainly transcribable in similar tropical geographies such as India. With favourable policies, infrastructure development and stakeholder collaboration, India could cultivate 2.8 million hectares of oil palm to achieve its goal of producing 11.20 lakh tonnes of crude palm oil by 2025-26. However, challenges such as climate adaptability, water availability, and nutrient management must be addressed to enhance self-sufficiency and reduce import reliance.

3.4 Impact on Soil Health and Environment

The imbalanced fertilizers application has adversely impacted the soil health over past few decades and caused damage to environment. Excessive use of inorganic fertilizers, particularly nitrogen and phosphorus-based, have led to altering soil pH and ultimately reducing absorption of nutrients by plant roots by making them unavailable due to high pH value. The high fertilizers application can lead to leaching into groundwater, or run-off during irrigation and cause contamination of water bodies. Additionally, nitrogen-based fertilizers are one of the sources for nitrous oxide, a potent greenhouse gas, which is responsible for global warming and ozone depletion. Further, beneficial microbes' population and their activities in the soil is impacted by the imbalanced fertilizers application, and this lowers the soil's capacity to sustain plant development and the resilience of the ecosystem as a whole. To mitigate these adverse effects, it is important to promote balanced fertilizer application, giving due consideration to soil testing, need based nutrient management, and sustainable agricultural techniques to maintain long-term soil health and environmental sustainability.

1. **Improved Soil Fertility:** Various studies have established the role of micronutrients in many soil functions including nutrient cycling and microbial activity. In recent study, scientists have found the role for zinc in the nitrogen fixation process of legumes. This finding, along with insights into the transcriptional regulator (Fixation Under Nitrate) has the prospect to transform pulses cultivation by enhancing crop efficiency and decreasing the use of inorganic fertilizers[34].

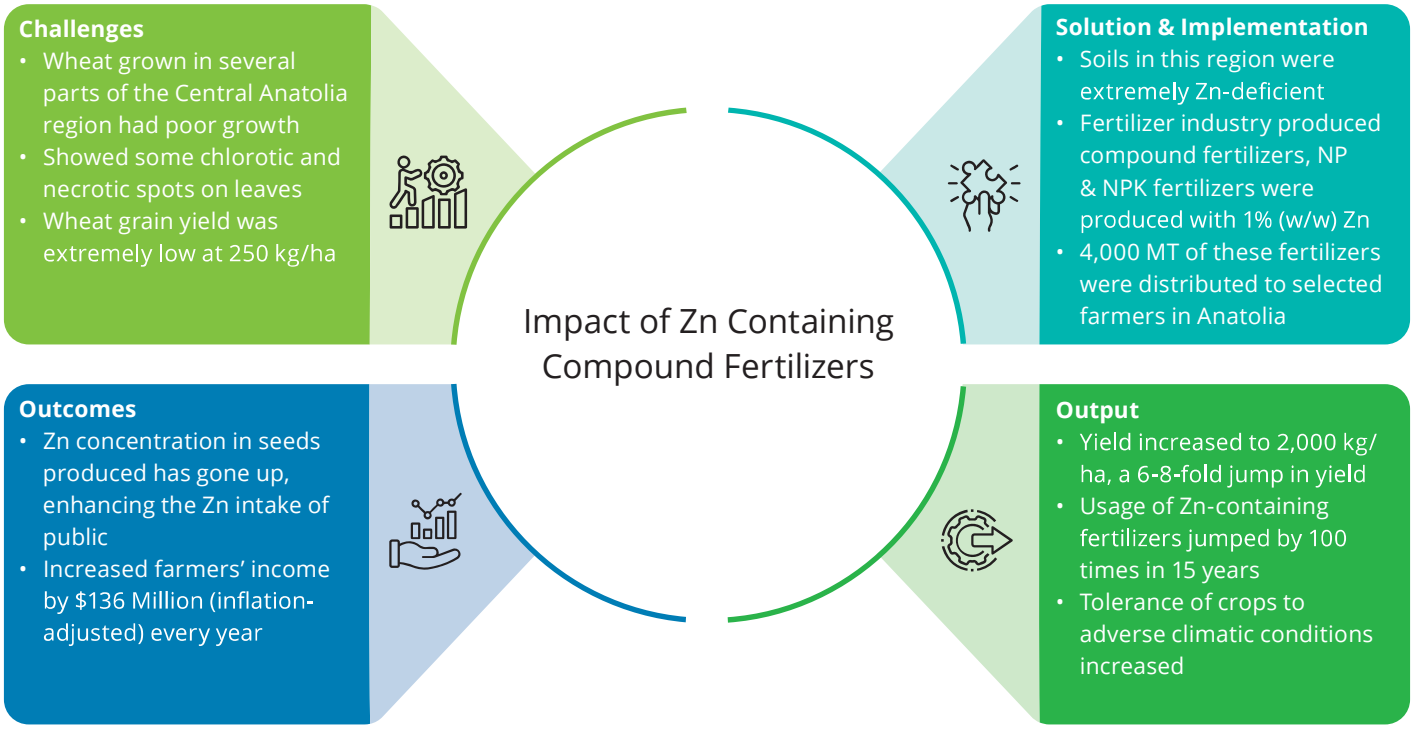
2. **Enhanced Soil Structure:** Studies have established the role of micronutrients in improving soil structure and soil aggregation. This improves overall soil structure, leading to better soil aeration, plant root activities, water infiltration, reduced soil erosion and drainage.

3. **Potential for Reduced Overall Fertilizer Use:** Crop and location specific nutrient recommendations can help farmers rationalize their overall fertilizer application. This can potentially lead to a reduction in the excessive use of NPK fertilizers and protect soil and water from the adverse impacts which are associated with excess nutrient runoff.

4. **Sustainable Practices:** Integrated nutrient management (INM) practices combining micronutrients with organic matter amendments can further enhance soil health and environmental sustainability.

[30] https://ourworldindata.org/palm-oil
[31] https://www.icra.in/Rating/DownloadResearchSpecialCommentReport?id=4278
[32] https://nmeo.dac.gov.in/NMEOUploadDocuments/BriefNMEOOPRoI_05052022_637873526665916004_OilPalm_India_Brief.pdf
[33] https://iiopr.icar.gov.in/pdf/FAQs.pdf
[34] https://scitechdaily.com/groundbreaking-discovery-how-zinc-could-change-farming-forever/

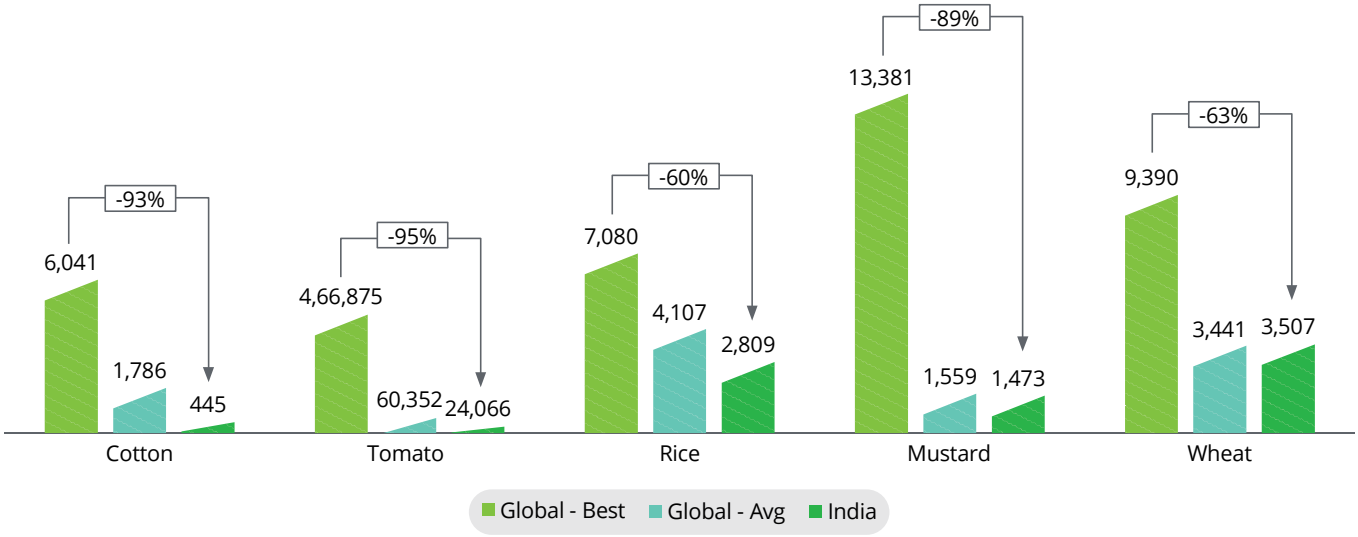
Case Study:
A case study on the impact of micronutrients on the yield of wheat crop in Turkey is illustrated below.



Use Case: Potential Agricultural Value Loss due to Micronutrient Deficiency:

India lags substantially in average yield of most of the agricultural and horticultural crops when compared with the global average yields in respective crops. When compared with the yield of the top-performing countries worldwide, Indian yields fall between 60-95% (Figure 9), highlighting significant room for improvement. One of the primary reasons for this low yield is the limited or no use of micronutrient fertilizers in Indian soils.

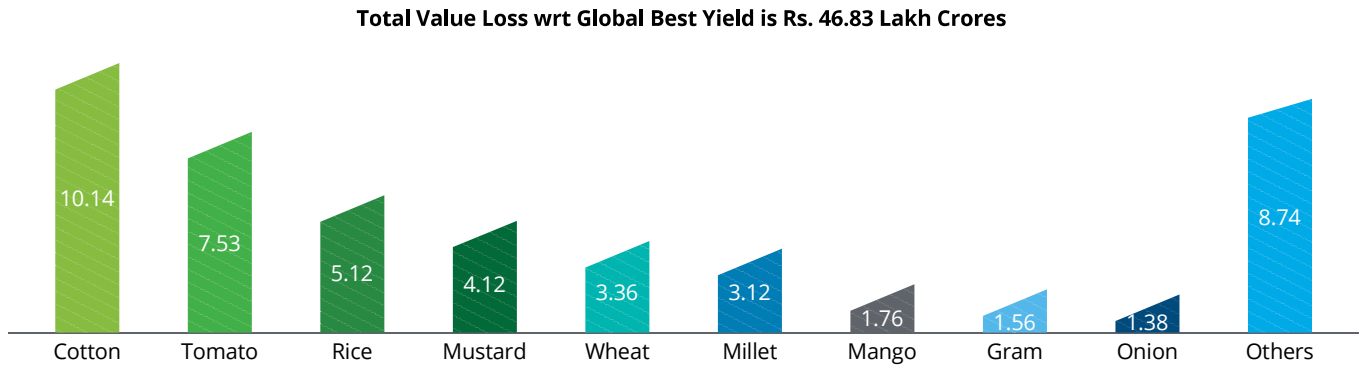
Figure 5: Comparison of Crops Yields in India, Global Best, and Global Average



Source: FAO; GoI; Deloitte Analysis

The yield gap for agricultural and horticultural crops potentially results in an estimated Rs. 46.83 Lakh crores (~USD 550 billion) loss in value (Figure 10). Studies have shown that the use of micronutrients can increase crop yields by up to 25%[35]. Of the total potential output value difference, nearly 7.02 lakh crores (~USD 84 billion) can be achieved by using micronutrients, assuming modest increase in yield by 15% due to recommended doses of micronutrients. This may translate to increased income to the farmers.

Figure 6: Value Loss to India due to Lower Crop Yields



Source: FAO; GoI; Deloitte Analysis

[35] Francess Sia Saquee et al. (2023), The Efficacy of Micronutrient Fertilizers on the Yield Formulation and Quality of Wheat Grains.

4. Fertilizer Sector and Micronutrient Market in India

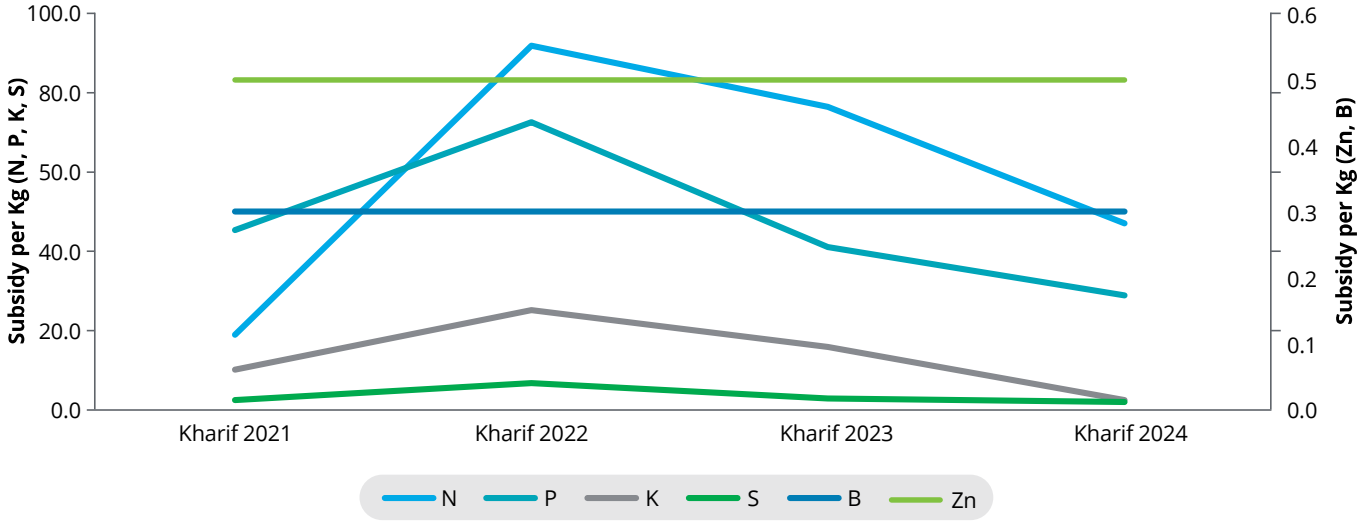
4.1 Fertilizer Sector in India

In the Indian fertilizer sector, urea dominates the market, accounting for 61% of the total 586 lakh MT volume in 2022-23. Other major fertilizers include Diammonium Phosphate (DAP), Muriate of Potash (MOP), and Single Superphosphate (SSP). Together, these four fertilizers provide primary source of N-P-K-S in Indian agriculture. In 2022-23, sales figures were as follows: urea at 357.3 lakh MT, DAP at 105.3 lakh MT, MOP at 16.3 lakh MT, other N-P-K complexes at 100.7 lakh MT, SSP at 50.2 lakh MT, and other fertilizers at 0.94 lakh MT[36].

Essential fertilizers are subsidized in India to encourage usage and make it affordable for farmers. In 2022-23, the total subsidy provided for urea and nutrient-based subsidy (NBS) were ₹1.65 lakh crore and ₹0.85 lakh crore, respectively[37]. The MRP of urea has been kept constant at ₹242 per 45 kg bag from 2014 through the Kharif season of 20242, wherein the Government has provided subsidy to manufacturers to cover their production and logistics cost. Under NBS, the Government provides fixed subsidy per kg of select nutrients present in the fertilizer. Figure 2 illustrates the nutrient-based subsidies for N, P, K, S, B, and Zn over recent years.

[36] Annual Review of Fertilizer Production and Consumption 2022-23, Indian Journal of Fertilizers
[37] Notes on Demands for Grants 2024-25, Department of Fertilizers, GoI

Figure 7: Nutrient Based Subsidy from Kharif 2021 to Kharif 2024

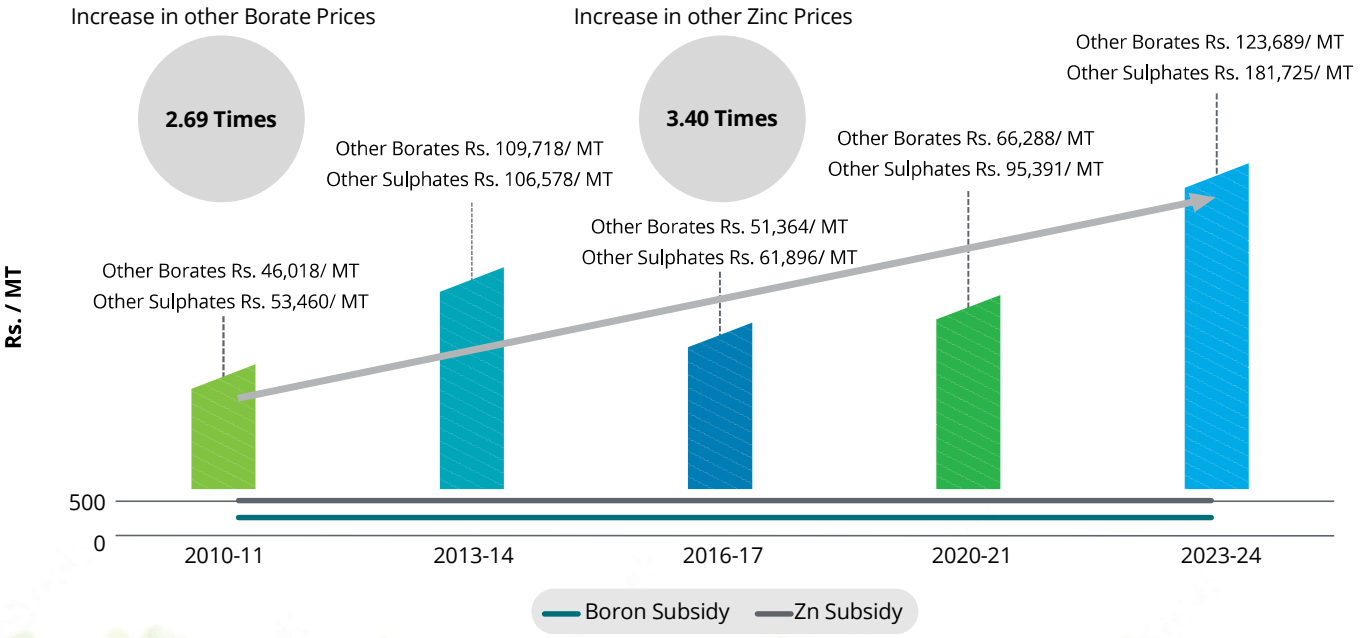


Source: https://fertiliserindia.com/india-sets-nutrient-based-subsidy-rates-for-phosphatic-potassic-pk-fertilizers-for-kharif-2024-season/; Nutrient Based Subsidy for P&K Fertilizers for Kharif 2024 (1st April to 30th September), Office Memorandum dated 1st March 2024, Department of Fertilizers, GoI

The subsidy provided under MDA scheme for Fertilizer Organic Manure, Liquid Fermented Organic Manure, and Potash Rice Organic Manure is ₹1500 per MT. The subsidy was introduced in 2023 and is provided to the entity marketing these products[38].

Fertilizer subsidies are adjusted periodically in response to domestic and international market conditions, with a focus on farmers interest and governmental priorities. However, the subsidy provided for fortification of P & K fertilizers with boron and zinc has remained constant since 2010-11 till Kharif 2024[39] (Figure 3). During this period of 2010-11 to 2023-24, the import prices (of India) has increased to 3.40 X for Other Sulphates category (which includes zinc sulphate) and 2.69 X for Borates (others).

Figure 8: Comparison of Micronutrient Subsidy and Raw Material Prices over the Years



Source: Trade State (Ministry of Commerce & Industry; Deloitte Analysis

[38] Guidelines on Market Development Assistance for promotion of organic fertilizers, Office Memorandum dated 20th September 2023, Department of Fertilizers, GoI

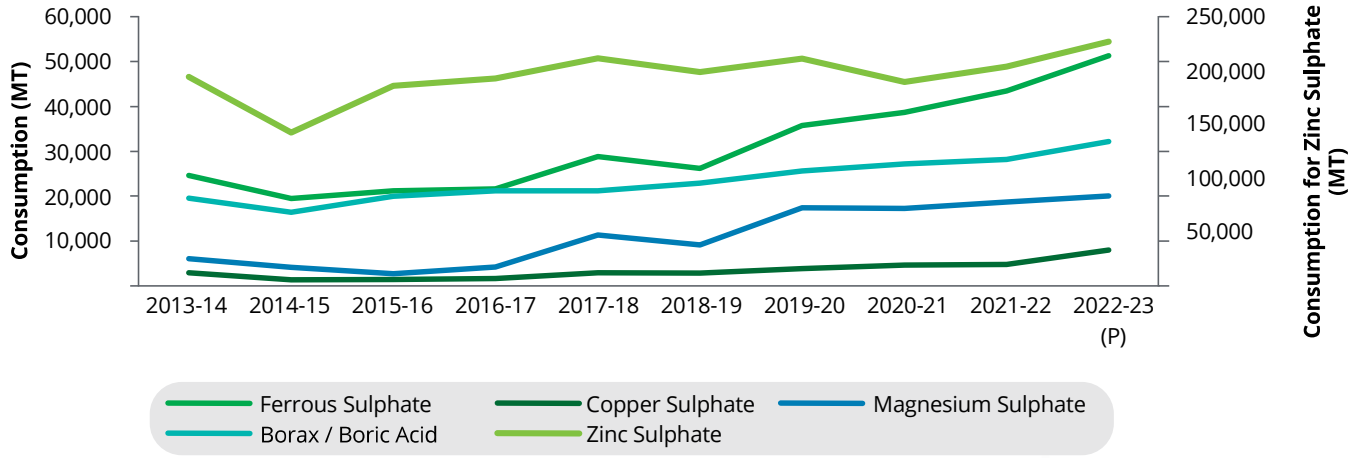
[39] Rajya Sabha Unstarred Question 1454, Increase in price of fertilizers, Department of Fertilizers, GoI

4.2 Micronutrient Market in India

The Indian micronutrient market is driven by zinc, boron, and iron, which are all significantly deficient in Indian soils. These micronutrients are used in various forms, primarily as straight fertilizers, and micronutrient mixtures. Additionally, they are available as chelated nutrients, fortified fertilizers, custom formulations, and slow-release options, providing diverse options to farmers for appropriate usage.

As per FAI, in 2022-23 (provisional data), 3.4 lakh MT of micronutrients were used in Indian agriculture, a growth of 38% from the previous year. Zinc sulphate accounted for the major consumption (66.5%) followed by ferrous sulphate (15%) and borax / boric acid (9.4%). The consumption of major micronutrients from 2013-14 to 2022-23 (ten-year period) is illustrated in Figure 4. The compounded annual growth rate (CAGR) of these major micronutrients is only 3.25% in this period, with zinc sulphate's CAGR at 1.56% while those of ferrous sulphate and borax / boric acid at 7.6% and 9.4%, respectively.

Figure 9: Consumption of Micronutrients in India – 2013-14 to 2022-23



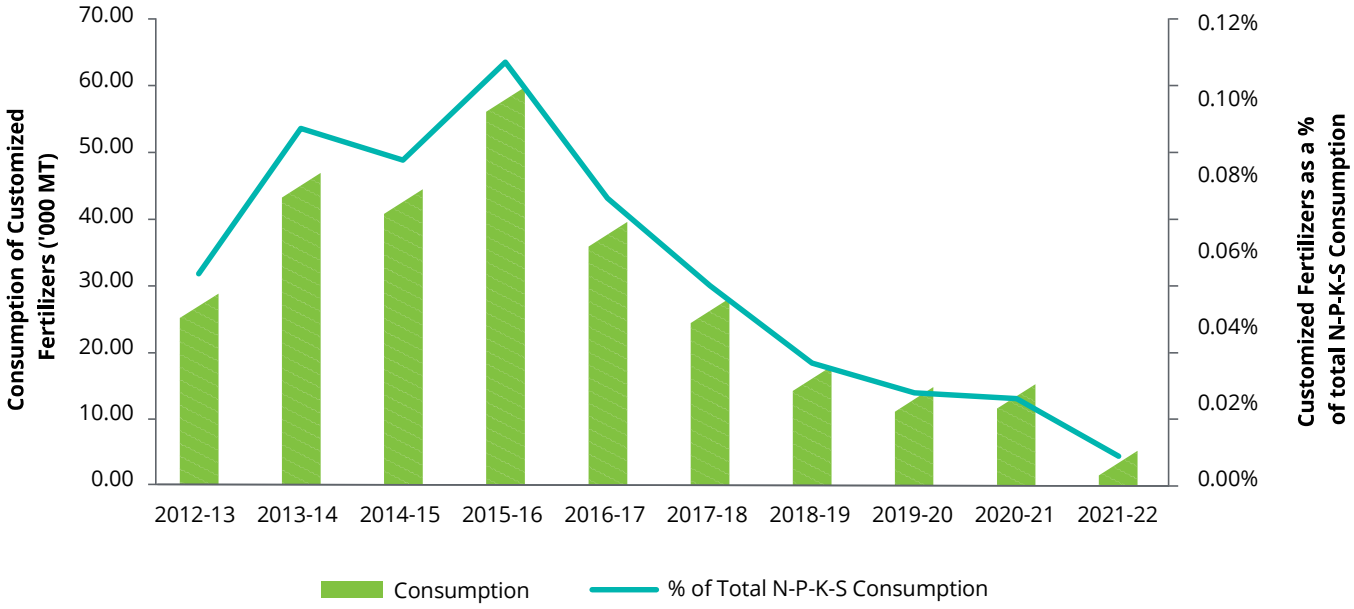
Source: Specialty Fertilizer and Micronutrient Statistics 2022-23, 12th Edition, FAI; P – Provisional

Micronutrient mixtures consist of various micronutrients formulated as per local soil conditions and further approved by respective state governments. In the fiscal year 2022-23 (provisional data), approximately 2.18 lakh metric tons of micronutrient mixtures in powder form and around 6.63 lakh liters in liquid form were consumed in the country.

Trend of Customized Fertilizers Consumption:

Customized fertilizers, tailored to address specific nutrient deficiencies or regional needs, were introduced to cater to varying soil conditions. Despite their potential to effectively address micronutrient deficiencies and support better crop health and yield based on site specific nutrient management (SSNM), their consumption has declined over the years. The ratio of customized fertilizers to total N-P-K-S fertilizer consumption has reduced from 0.11% during 2015-16 to around 0.01% in 2021-22. (Figure 5).

Figure 10: Consumption of Customized Fertilizers in India – 2013-14 to 2022-23



Source: Specialty Fertilizer and Micronutrient Statistics 2022-23, 12th Edition, FAI; Fertilizer Statistics 2021-22, FAI; Department of Fertilizers, GoI

5. Policy Assessment

As one of the world's largest agrarian economies, India faces a dual challenge: ensuring nutritional security of increasing population while enhancing farmers' income. Micronutrients can play an important role in achieving both the objectives. However, the current policy framework governing micronutrient fertilizers in India needs to be aligned with global best practices in this area. Addressing the micronutrient deficiency in soils goes beyond increasing agricultural yield or economic output; it also encompasses global agenda concerning food security, public health, and environmental sustainability. Consequently, this section provides a detailed analysis of global policies on micronutrient fertilizers within the Indian context.

5.1 Policy Initiatives for Promoting Fortified Fertilizers

To bring the parity between the cost of the fortification and the mandated MRP for subsidized fertilizers, Government of India introduced a policy on fortified fertilizers in 2008. This policy allows the manufactures of subsidized fertilizers to fortify fertilizers, up to 20% of their production, with Zinc and Boron. Under this policy these manufacturers were permitted to markup the fortified fertilizers by 10% over the notified MRP. The Government provides an additional subsidy of ₹500 per ton for zinc and ₹300 per ton for boron fortification under the Nutrient Based Scheme (NBS).

5.2 Financial Assistance for Micronutrients

The Government, through the National Food Security Mission (NFSM) is supporting the application of micronutrients in crops to improve nutritional content of the food produced through agronomic biofortification. Apart from the subsidy provided through NBS, the below table provides brief on other schemes providing subsidy for micronutrient application.

Table 1: Overview of Schemes (other than NBS) Providing Subsidy for Micronutrient Application

NFSM – Wheat, Rice, Pulses	Financial assistance of INR 500 per ha or 50 per cent of cost whichever is less - zinc sulphate, boron (borax decahydrate, borax pentahydrate), iron (ferrous sulphate)
NFSM – Nutri-Cereals	Financial assistance of INR 500 per ha - Zn, B, and Fe
NFSM – Oilseeds	Need based supply of plant protection chemicals, insecticides, fungicides, bio-pesticides, weedicides, bio-agents, micronutrients, bio-fertilizers, etc., at 50% of the cost limited to INR 500 per ha
National Mission for Sustainable Agriculture	Under soil health management component, financial assistance for micro-nutrients - 50 per cent of the cost limited to INR 500 per ha
National Mission on Edible Oils - Oil Palm	During gestation period of 4 years, assistance will be given for maintenance @ 50% of the cost limited to Rs. 50,000/ha in NE/ A& N Islands & Rs. 42,000/ha for General States.

Source: Re-vamped NFSM Operational Guidelines (2018-19 to 2019-20), Ministry of Agriculture and Farmers Welfare, August 2018; National Mission for Sustainable Agriculture, Operational Guidelines, February 2017
https://nfsm.gov.in/Guidelines/NMEO-OPGUIEDELINES.pdf

5.3 Soil Health Card

The Soil Health Card (SHC) scheme was launched in 2014-15, by the Ministry of Agriculture & Farmers' Welfare. The main objective of the scheme was to facilitate soil health assessment and provide farmers with crop and location specific fertilizer recommendation. SHC provides information on macronutrients (nitrogen, phosphorus, potassium), secondary nutrients (calcium, magnesium, sulphur), micronutrients (iron, zinc, boron, copper, manganese), soil organic carbon, pH, and electrical conductivity.

This scheme is vital in promoting INM by encouraging farmers to use chemical fertilizers (including micronutrients) judiciously alongside organic manure to improve and sustain soil health. SHC also promotes establishment and improvement of soil testing laboratories, and quality control labs for fertilizers (including organic and bio fertilizers) as a sub-component. Additionally, the government has set a target for setting up 7,500 Village level soil testing laboratories till 2026, making soil testing more accessible for farmers.

5.4 Nutrient Based Subsidy (NBS)

NBS was launched in 2010 to encourage the use of different N-P-K fertilizers and reduce the overuse of urea. Under this scheme, Government is providing 25 grades of P&K fertilizers and 16 grades of complex fertilizers to farmers at subsidized prices. Additional financial assistance is provided on fertilizers fortified with secondary nutrients and micronutrients such as boron and zinc as per the Fertilizer Control Order (FCO). Although, the NBS Scheme offers financial assistance for N, P, K, S, Zn, and B, however, various fortified and customized fertilizers, specified in the Fertilizer Control Order (FCO), are not included under the NBS Scheme.

5.5 Micronutrient mixtures notifications by the states

Micronutrient mixtures are manufactured according to the regional and crop specific requirements. These are more popular in South and West region, however, their availability to the farmers is governed by the notifications issued by the Government. The Government of Tamil Nadu has notified 14 grades of micronutrient mixtures while Government of Maharashtra has notified 11 grades of micronutrient mixtures. Following table depicts state wise notification of micronutrient mixtures grades which reflects scope to expand the portfolio of notified micronutrient mixtures in tandem to state's and crop specific requirements.

Table 2: Micronutrient mixtures notified by the states

S. No.	States	Total Grades notified
1.	Andhra Pradesh	7
2.	Assam	2
3.	Bihar	6
4.	Chhattisgarh	6
5.	Delhi	7
6.	Goa	4
7.	Gujarat	5
8.	Himachal Pradesh	3
9.	Jharkhand	4
10.	Karnataka	5
11.	Kerela	2
12.	Madhya Pradesh	2
13.	Maharashtra	11
14.	Odisha	7
15.	Punjab	3
16.	Rajasthan	4
17.	Tamil Nadu	14
18.	Telangana	7
19.	Uttar Pradesh	5
20.	Uttarakhand	3
21.	West Bengal	5

Source: Micronutrients Statistics by FAI; Reports on Zonal conference on fertilizers (State department of Agriculture); HLS Tandon, Micronutrient Handbook – from research to application, Fertilizer Development and Consultation Organization.

6. Global Policies on Micronutrients

Globally, the countries have formulated policies on micronutrient fertilizers to focus on enhancing soil health, agricultural productivity and resolving nutrient deficiencies in food systems. The fundamental principles include developing nutrient management guidelines, setting quality standards, and promoting research on the benefits of micronutrients for crops. Countries also provide incentives to encourage their use, along with training programs for farmers to ensure effective application.

6.1 Global Initiatives on Micronutrients

Countries across the world have taken specific initiatives that have encouraged the use of micronutrient fertilizers and have provided support to the micronutrient industry. Some of the key initiatives by different countries are provided in the table below.

Table 3: Initiatives by Countries on Micronutrients

Country Name	Name of Initiative	Description	Impact
Turkey	Boron Fertilization Program	Turkey implements a Boron Fertilization program to improve Boron levels in agricultural soils through use of boron-enriched fertilizers. This program is critical for maintaining soil fertility, enhancing crop quality, and increasing yields, especially for Boron-sensitive crops like fruits and vegetables.	Improved crop production and quality, leading to increased exports of Boron-sensitive crops. Farmers have reported enhanced soil health.

Country Name	Name of Initiative	Description	Impact
United States of America	Extension Service programs for Zinc application & Environmental Quality Incentives program (EQIP)	The USDA's extension service provides research-based information and outreach programs to educate farmers on Zinc application in agriculture. Guidance on soil testing, nutrient management plans etc. EQIP program provides financial assistance to farmers adopting practices that improve soil health including the application of micronutrients.	Programs has facilitated knowledge transfer and adoption best practices. Resulted in improved crop health and yields.
Brazil	Research on Micronutrient Management	Conducts research on micronutrient management tailored to Brazil's diverse Agro-ecological zones.	Farmers have adopted improved nutrient management practices, resulting in sustainable agricultural intensification and economic benefit.
China	Soil Testing and Micronutrient recommendations program	Program promotes soil testing to assess zinc and boron levels in agricultural soils. Based on soil analyses, customized recommendations are provided to farmers for micronutrient fertilization to optimize crop growth, quality, and yield.	Adoption of soil testing and micronutrient recommendation has led to improved nutrient management practices among farmers.
Australia	Zinc and Boron fertilization practices	Promotes best practices for Zinc and Boron fertilization to optimize soil health and crop productivity. The program includes research, extension services and regulatory oversight to ensure sustainable nutrient management in agriculture.	Increased adoption of balanced fertilization practices.
Canada	Soil health & Micronutrient management initiative	Canada's initiative focuses on enhancing soil health and managing micronutrients like zinc and boron through research, extension services, and policy support. The program aims to improve nutrient use efficiency and resilience of Canadian agriculture.	Farmers have adopted innovative approaches to micronutrient application.
The Netherlands	Precision farming for micronutrient management	The Netherlands emphasizes precision farming techniques for micronutrient management, including Zinc and Boron, to optimize resource use efficiency and reduce environmental impacts. The program integrates data-driven decision-making, and farmer training.	Implementation of precision farming has led to precise application of micronutrients.

Source: https://www.tarimorman.gov.tr/
https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives
https://www.embrapa.br/en/international
https://ap.fftc.org.tw/article/769
https://www.agriculture.gov.au/
https://agriculture.canada.ca/en/agricultural-production/soil-and-land/soil-nutrients/nutrient-management-planning
https://www.wur.nl/en/research-results/dossiers/file/dossier-precision-agriculture.htm
National Agrofood Policy - Ministry of Agriculture and Food Security (kpkm.gov.my)

6.2 Global Trade Policies

Recognizing the importance of micronutrients in enhancing agriculture productivity, and public health, many countries have implemented import polices to facilitate efficient and cost-effective imports of micronutrient fertilizers. Below table provide details on few notable country-specific trade policies.

Table 4: Global Initiatives on Micronutrient Trade Policies

Country	Policy
United States of America	• USA under the Harmonized tariff schedule allow for duty-free importation of certain agricultural chemicals and fertilizers, including zinc and boron products. • USA has trade agreements with countries eg. the United States-Mexico-Canada Agreement, which facilitate the import of agricultural inputs, including micronutrients, from neighboring countries with minimal tariffs.
Brazil	• Brazil offers subsidies and financial incentives for the use of micronutrient fertilizers, which indirectly support their import by making them more affordable for farmers.
European Union	• EU provides various subsidies and grants under the Common Agricultural Policy to support the use of micronutrients, encouraging their import and use in farming practices. • EU's Common External Tariff policy sets low or zero tariffs on essential agricultural inputs, including zinc and boron fertilizers, for member states.
China	• Offers import tax exemptions on essential agricultural inputs, including zinc and boron fertilizers, to promote agricultural productivity. • Government engages in bulk purchasing and strategic reserves of key agricultural inputs, including micronutrients, to stabilize prices and ensure availability

Source: https://dtb-agritrade.com/wp-content/uploads/2021/05/ChinaVAT_Study.pdf
https://www.fao.org/4/ab981e/ab981e0c.htm
https://hts.usitc.gov/
https://ustr.gov/trade-agreements/free-trade-agreements/united-states-mexico-canada-agreement
https://www.reuters.com/article/markets/us/brazil-fertilizer-industry-wants-import-tariff-idUSN11118960/
https://agriculture.ec.europa.eu/common-agricultural-policy_en#:~:text=The%20common%20agricultural%20policy%20(CAP,and%20keeps%20rural%20areas%20vibrant
https://taxation-customs.ec.europa.eu/customs-4/calculation-customs-duties/customs tariff_en#:~:text=The%20'Common%20Customs%20Tariff'%20(,and%20where%20they%20come%20from.

6.3 Registration Process of Fertilizers

Enabling the Business of Agriculture (EBA) 2019 report[40], published by the World Bank Group, provided valuable insights into the regulatory framework affecting agriculture in various countries. The study provided a measure of progress and identify regulatory obstacles to market integration and entrepreneurship in agriculture.

As per the EBA report, India ranked 54th (score: 62.23) among the 101 countries. Registering fertilizers was one of the key indicators in EBA report which covered time to register a new fertilizer product (days), cost to register a new fertilizer product (% of income per capita), and quality of fertilizer regulation index (0-6). Tables 4 and Figures 11-12 present comparative analyses of India's performance against global leaders, other South Asian nations, and top agricultural countries worldwide[41].

[40] Enabling the Business of Agriculture, The World Bank
[41] Enabling the Business of Agriculture, The World Bank

Table 5: India's Performance vs Global best Performers in Fertilizer Regulations

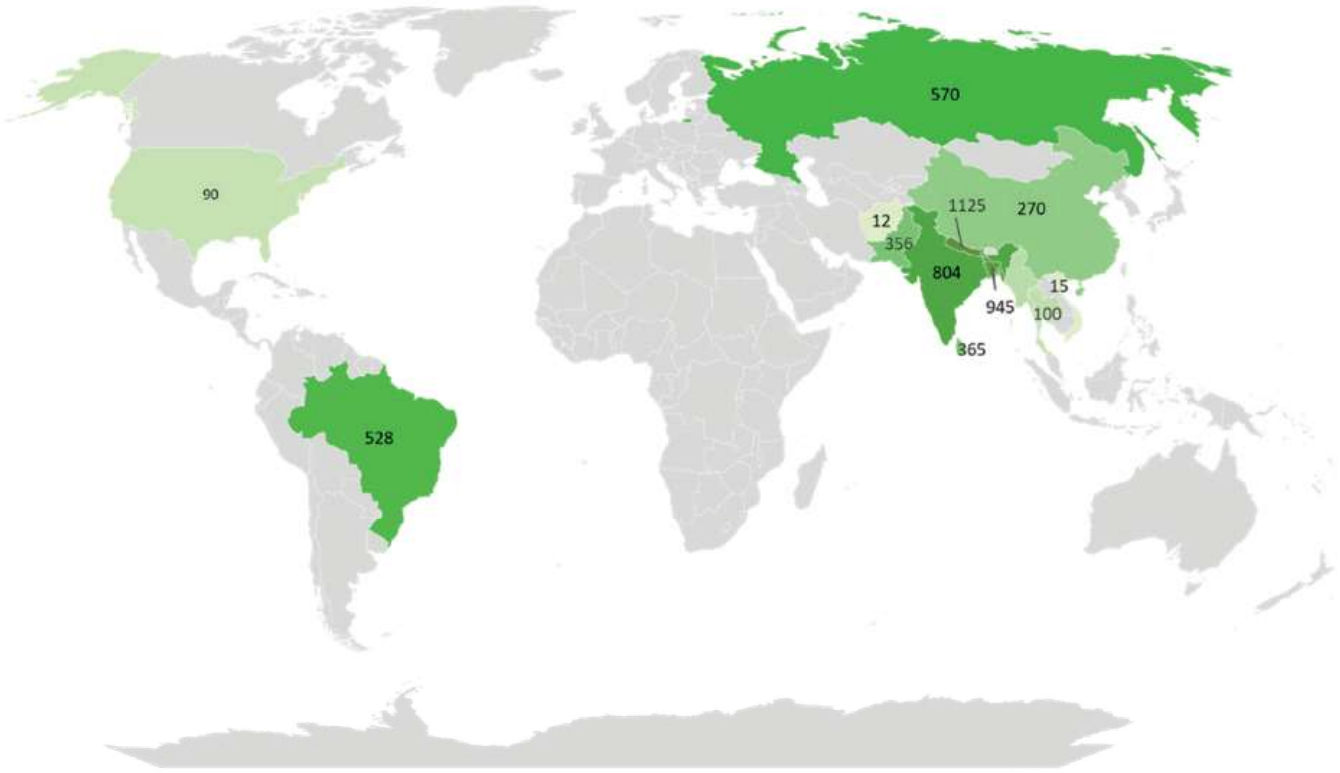
Indicator	Country establishing best Regulatory Performance	Best Regulatory Performance	Worst Regulatory Performance	India's Performance
Cost to register a new fertilizer product (% of income per capita)	Armenia, China, Croatia[@]	0.0	539.1	14.0
Quality of Fertilizer regulation Index (0-6)	Austria, Belgium, Switzerland[&]	6	0	4

Notes: [@]In another 22 countries, it costs 0% of income per capita to register a new fertilizer product.
[&]Another 19 countries score 6 out of 6 on the quality of fertilizer regulation index.

While the EBA report applauded the India's stronger regulatory framework in terms of the quality of fertilizer regulation index compared to other South Asian countries, however, India's ranking in the time taken to register a new product was fourth among its South Asian peers.

When compared to the top 5 agricultural producing countries namely China, USA, Brazil, India and Russia, India must prioritize establishing a conducive policy framework to streamline the registration process for new fertilizer products.

Figure 11: Time Required for New Fertilizer Product Registration (Days)



6.4 Comparison on Registration Process in Different Countries

Registration Process in few countries			
Country	**No. of Days**	**Efficacy Trial Required**	**Registration Process in Brief**
Austria, France, Germany, UK (EU Countries)	Zero	No	Based on fertilizer product categories and raw material, fertilizer manufacturers to comply with different conformity assessment procedures. Fertilizer manufacturers are required to prepare technical materials and apply for conformity assessment to a Notified Body accredited by the European Union. Once the Notified Body determines that the fertilizing product meets compliance requirements, it issues a certificate to the manufacturer. The basic required information for conformity assessment procedures includes: • General description of the fertilizer product • List of raw materials • Manufacturing process • Test reports • A list of the harmonized standards;
USA	90	No	Product should meet the minimum specifications described in the Act. Manufacturer is required to submit application to each State and normally takes 2 weeks for registration Label claims are reviewed and post review, the registration is granted for sale or distribution
Australia	20	No	Approval is given in 20 days to import
Vietnam	15	No	Automatic approval based on minimum nutrient content-Label Claim
Malaysia	NA	No	No registration required

Source: Enabling the Business of Agriculture, The World Bank
https://www.consilium.europa.eu/en/press/press-releases/2024/01/22/fertilisers-labelling-council-and-parliament-strike-provisional-deal-to-make-fertilisers-labelling-clearer-simpler-and-more-digital/
https://www.ncagr.gov/divisions/plant-industry/seed-and-fertilizer/registration-commercial-fertilizer-products

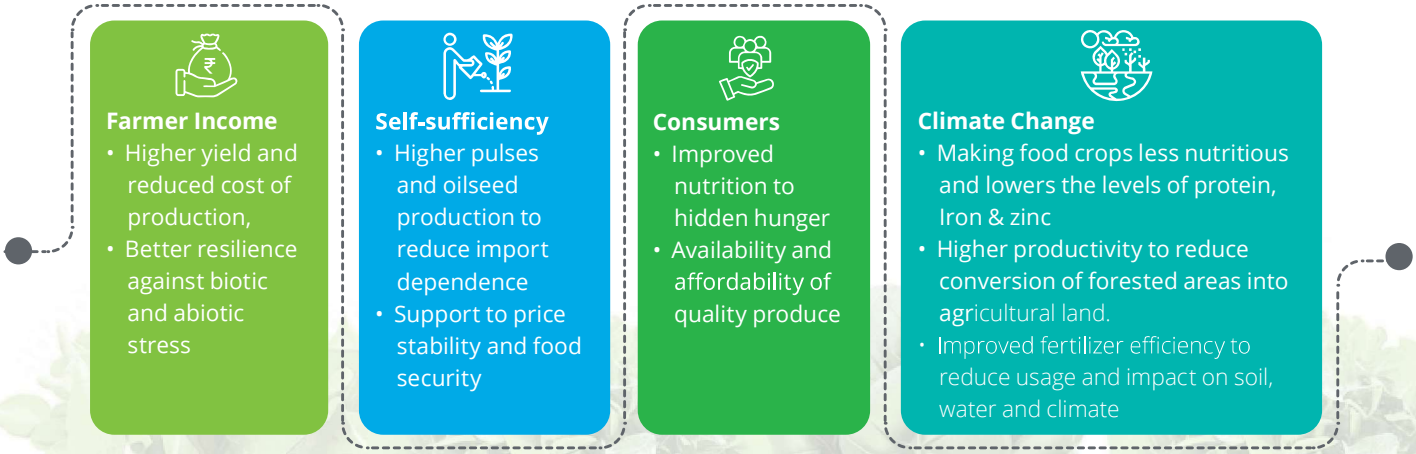
7. Policy Recommendations to Promote Use of Micronutrients in Agriculture

Micronutrient deficiencies are a common occurrence and huge challenge in Indian agriculture, impacting crop productivity, reducing profitability of farmers, affecting produce quality, and its nutritional value. To address micronutrient crisis in Indian agriculture, a multi-faceted policy framework is recommended. The policy must address awareness among farmers, improving access to micronutrient fertilizers, and incentivizing their use.

Several studies have confirmed that micronutrient applications can enhance yields, improve product quality and nutritional value, and mitigate the impacts of biotic and abiotic stresses, particularly under water stress conditions. Further, India has increasingly relied on imports for key pulses and oilseeds, reflecting a growing dependence on imports for these commodities and increased burden on forex reserves.

A favorable policy framework on micronutrients application in agriculture will promote sustainable agricultural practices, enhance food security, and will contribute to improved public health. Balanced and equitable fertilizer use has the potential to achieve the following key objectives of the Government.

Figure 12: Key Pillars for Policy Design in Agriculture



While the government and industry have made several efforts to promote the use of micronutrients in agriculture, extensive application is still hindered by factors such as limited awareness among farmers, availability, and affordability of micronutrient fortified fertilizers. Micronutrient use remains predominantly limited to cash crops like vegetables, fruits, and rice (due to Khaira disease). It is important to encourage widespread adoption of balanced fertilizer application for crop production to achieve above objectives and unleashing the underlying strengths of Indian agriculture to achieve the target of USD One Trillion contribution of agriculture to GDP.

7.1 Ease of Micronutrient Product Registrations

New fertilizer registration is essential to maintain control over quality and type of fertilizers available for sale to the farmers. A robust and effective registration mechanism, supported by a regulatory framework, is crucial for ensuring farmers' confidence in fertilizers regarding presence of sufficient nutrients in fertilizers to support crop growth while ensuring that heavy metals or other residues are within prescribed limit. It also ensures that the fertilizer products comply with the environmental and safety requirements[42].

An efficient registration procedure is crucial for introduction and commercialization of innovative fertilizer products in a timely and cost- efficient manner. In India, the role of NPK with other micronutrients and their reaction in the soil has been well established by extensive testing on different crops and in different climatic zones. There have been evidences that a soil analysis can be used to estimate the amount and type of fertilizer needed to supplement the nutrients in the soil[43].

For new fertilizer registration in India, the companies are required to undertake multilocation trials for at least two crops over two seasons and the trial report is submitted for clearance and approval by competent authority before the fertilizer is included in the FCO through gazette notification as qualifying for use by farmers. Subsequently, the fertilizer companies are required to apply for licenses in each state for the sale of fertilizer products. This increases the cost of bringing new fertilizers to market and is often passed to farmers, making innovative fertilizers more expensive and less accessible.

The system of 'Label-Based Product Registration and Quality Control' has been widely used in various countries and may be considered for implementation in India as well. Comprehensive guideline may be developed for maximum and minimum specifications for micronutrients in fertilizers, incorporation of other important micronutrients in FCO and Label-Based Product Registration and Quality Control by a Task Force. The Task Force may also be entrusted with comprehensive study on recent advancements in the nutrient delivery technology to the plants and design the nutrient specification limits. This would help companies to comply with fertilizer regulations more effectively and efficiently. The fertilizer manufacturers could streamline the introduction of new fertilizer products without requiring extensive efficacy and toxicity trials by adhering to established specifications for micronutrients. This would establish a clear framework for compliance, simplifying the approval process and fostering consistency in product quality standards throughout the fertilizer industry.

A similar initiative was undertaken by the Government for water-soluble fertilizers (WSF) vide order dated 24th October 2015. The order states that entities planning to sell water-soluble fertilizer must inform the competent authority about their product details and intention to sell. They may start selling the product thirty days after notifying the authority. Additionally, they must advertise the product details in two widely circulated local daily newspapers in the concerned districts at least 30 days before selling, offering for sale, or engaging in the business of selling the product. This has reduced the new fertilizer product registration time significantly to 60-90 days on State Marketing Licenses.

The Government may also consider registration for specialty fertilizers (non-subsidized) to be exported in a time-bound manner. Such registrations will allow the manufacturers to expand production capacities and achieve economies of scale. This also aligns with the government's "Make in India" initiative and improve domestic manufacturing capabilities. Similar registration for exports is already allowed by Central Insecticide Board under "9(3) (export)" of the Insecticides Act, 1968.

7.2 Creating Unified Application System for Product Registration and Licensing for Fertilizers

The industry has felt compelling need for creating a unified application system for product registration and licensing in the fertilizer industry. Currently, after a new

[42] https://www.fertilizerseurope.com/agriculture-environment/fertilizing-products-regulation/
[43] https://ag.umass.edu/greenhouse-floriculture/greenhouse-best-management-practices-bmp-manual/soil-testing

fertilizer product is included in the FCO through Gazette Notification and is deemed suitable for farmers' use, fertilizer companies must apply for licenses in each state where they intend to sell new products. Obtaining licenses from multiple states is cumbersome and time-taking exercise and requires navigating through varied applications, documentations, and timelines and can lead to delays in launching new products across the country simultaneously.

Developing a unified national application system for licensing process would mitigate above mentioned challenges. This would standardize procedures, reduce administrative hurdles, and reduce costs associated with multiple state applications. It would also expedite the approval timeline, ensuring timely access to beneficial agricultural products for farmers nationwide.

7.3 Periodic Review of Fortified Fertilizers Subsidy under NBS Scheme

The Government has launched the Nutrient Based Subsidy Scheme for providing subsidy on Zinc and Boron fortification. However, the production and demand for fertilizers fortified with zinc and boron have not seen noticeable increase despite government support and inclusion of 35 fortified fertilizers in the FCO.

Since 2010-11, the subsidy for zinc and boron has remained unchanged, while the prices of other sulphates (including zinc sulphate) and other borates have increased significantly during the corresponding period. The rising cost of fortification of fertilizers with micronutrients pose a barrier for farmers in large scale adoption of the fortified fertilizers.

Establishing a Committee of Experts to analyze the production costs of fortified fertilizers and current subsidies, and to propose policy adjustments in this domain, could be pivotal in fostering widespread adoption of micronutrient-enhanced fertilizers.

Alternatively, the Government may contemplate implementing the Production Linked Incentive scheme for fortified fertilizers. This initiative would ensure that fertilizers enriched with essential micronutrients are accessible to the farmers at an affordable price.

7.4 International Year of Micronutrients

Micronutrients are playing very critical role in agriculture by improving plant growth, optimizing nutrient utilization, enhancing crop yields and quality, improving farm profitability, and ensuring food security. However, lack of awareness among farmers poses a significant barrier to widespread adoption of micronutrients in agriculture.

Although, efforts to raise awareness about the importance of micronutrients in agriculture are ongoing through various initiatives by agricultural research institutions, governmental bodies, fertilizer industry and international organizations concerned with food security and sustainable agriculture. A persistent effort is required to promote the use of micronutrient fertilizers in farming practices.

The International Year of Crop Nutrition (IYOCN) may be aimed to demonstrating importance of the micronutrients among various stakeholders including farmers, scientist, extension workers, policy makers, nutrition experts, and public health workers while synergizing global efforts to address challenges associated with micronutrient deficiencies.

7.5 Review of GST and Import Duty Structure

The micronutrient fertilizers attract higher Goods and Sales Tax (GST) rates of 12-18% whereas bulk fertilizers are levied with 5% GST. The Central Bureau of Indirect Taxes has underlined the following in Schedule I, S. No. 56 and Chapter / Heading / Sub-heading / Tariff item 28:

Fertilizer products with Micronutrients in other categories in FCO Schedule 1, Part (A), namely, 1(h) Fortified Fertilizers and 1(k) Liquid Fertilizers are also considered under 'Micronutrients'

The micronutrients have been recognized as the fertilizer products and listed under FCO and are manufactured by the entities registered under the same order. The disparity in GST rates has resulted from the reclassification of micronutrients from Chapter 31 to Chapter 28 (inorganic chemicals) effective from 6 April 2016.

Industry leaders reiterate the need for reforms in GST slabs for micronutrient fertilizers and raw materials used in production with end- use monitoring. It may streamline compliance processes for fertilizer industry, easing administrative complexities and developing a supportive policy framework to promote micronutrient fertilizers. Besides, consistent GST rates would enhance affordability of micronutrient to farmers and improve balanced nutrient application in agriculture through streamlining prices. The balanced application of bulk fertilizers and micronutrients could also help in productivity enhancement and self-sufficiency in oilseeds and pulses. To check the possible diversion of raw materials for other industries, the end- use quantity of raw material may

be monitored through Point-of-sale machines-based fertilizer distribution, innovative digital technologies and the GST relaxation may be considered accordingly. An expert committee may be established to conduct a thorough study on GST rationalization and propose recommendations to the Department of Agriculture & Farmers Welfare for deliberation in the GST Council.

7.6 Digital Crop Booking and Customized Fertilizer Recommendation

Agri-tech are disrupting various spheres of agriculture and soil health assessment can also be efficiently undertaken with the use of advanced technologies. The recent initiatives of the Ministry of Agriculture and Farmers' Welfare (Krishi MApper and Agri Stack) may be leveraged along with advanced technologies such as artificial intelligence and machine learning to optimize soil nutrition practices. The soil micronutrient assessment may be undertaken using the remote sensing and state-wise / district-wise micronutrient fertility maps may be prepared using geographical information system (GIS) software particularly in uncovered areas. Additionally, by analyzing soil conditions, weather patterns, and crop-specific requirements, famers may be provided customized fertilizer recommendations tailored to specific crop and location requirement. This will facilitate in enhancing crop productivity, precision application of macro and micro-nutrient application while minimizing environmental impact.

7.7 Strengthening Soil Testing Labs for Micronutrient Testing Capabilities

In 2014-15, the Indian government launched the soil health card scheme aimed at evaluating the nutrient status of soil. As part of this initiative, the government is also supporting the establishment of soil testing laboratories across the country. However, the soil testing facilities remain largely unutilized due to lack of awareness among farmers, and limited equipment for analyzing micronutrients.

The government may leverage the expertise of private players and fertilizer industry to further strengthen soil testing facilities and improve the efficacy of Soil Health Card scheme under public- private partnership. This initiative can improve the accuracy, efficiency, and scalability of soil testing operations.

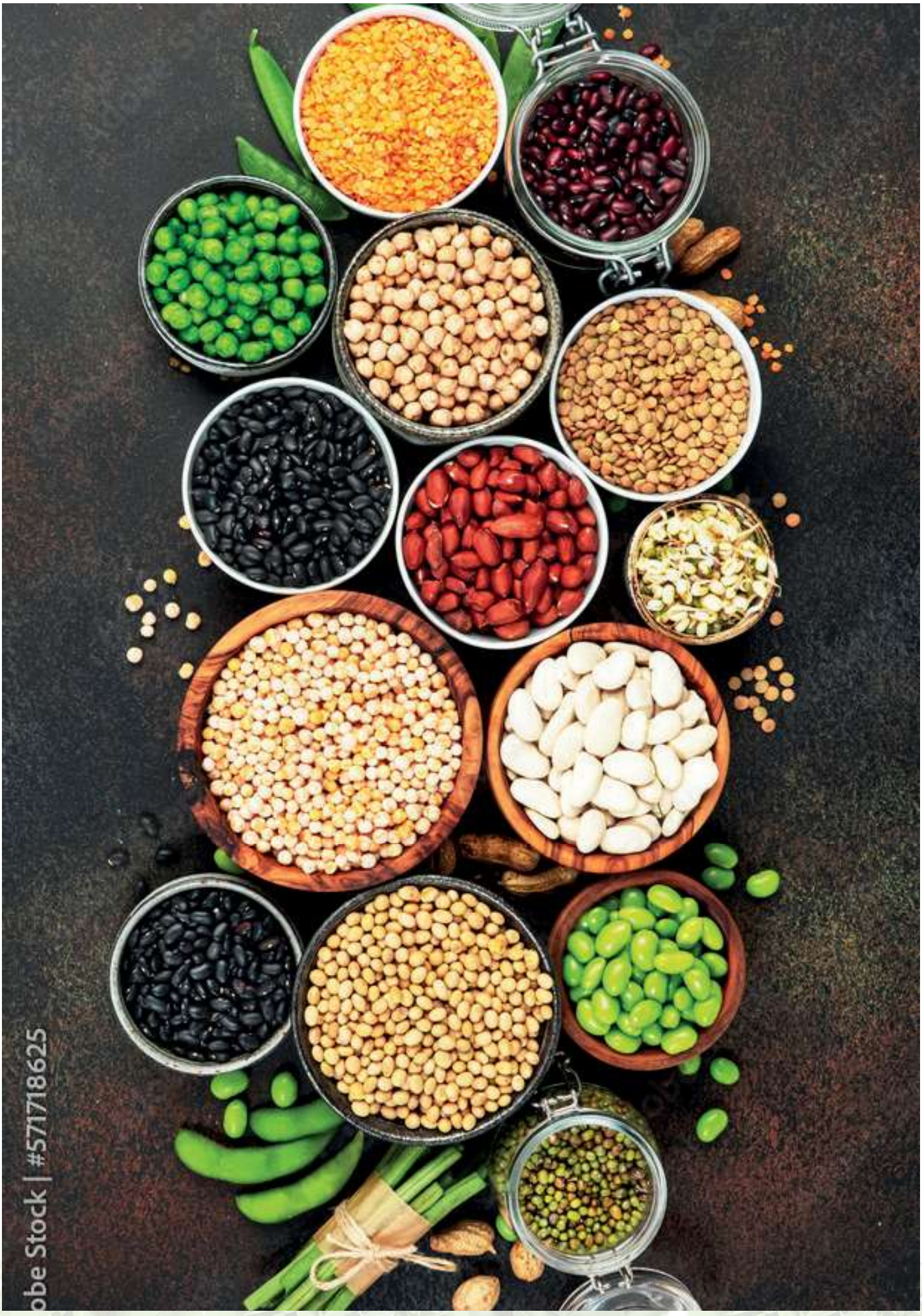
8. Conclusion

Micronutrients play an indispensable role in the future of Indian agriculture, with their potential to drive higher growth, enhance food security, and promote sustainable farming practices. The past few decades have witnessed significant strides in achieving self-sufficiency in major grains through the application of macronutrient fertilizers. However, the oversight of micronutrient requirements has led to a pressing need for a renewed focus on these essential elements.

The current state of micronutrient deficiencies in Indian soils—such as those of zinc, boron, iron, manganese, and copper—underscores a critical challenge that must be addressed to sustain agricultural productivity. The low and declining crop response to the fertilizers is resulting due to continuous nutrient mining of the soils without adequate replenishment of nutrients to the desired extent. The adoption of micronutrient fertilizers has been sluggish, hindered by factors such as high costs, limited awareness, and complex regulatory processes. This highlights the need for adoption of integrated nutrient management for enhancing crop yield, quality, and resilience.

To overcome these obstacles, a comprehensive policy reform is necessary, including simplifying the registration process for micronutrient products and improving ease of doing business for fertilizer companies. The government has undertaken several policy initiatives in the past to enhance adoption of micronutrients by the farmers, further strengthening of micronutrient policy is crucial for ensuring food and nutritional security, sustainable agriculture production and enhancing farmers' income. Concerted efforts from policymakers, agricultural researchers, industry stakeholders, and farmers themselves are essential to address the current gaps in awareness, accessibility, affordability, and distribution for widespread adoption of micronutrient-enriched fertilizers. Drawing parallels from global best practices, enabling policy environment may be successfully implemented further for enhancing availability and affordability of micronutrients for agriculture usage.

There are many fascinating technological changes taking place in fertilizer sector for delivery of nutrients to the plants and these changes are bringing improved efficiency, precision, safety, apart from other gains. The policy makers could adopt a holistic approach to establish enabling policy framework that foster innovations in micronutrient sector and promote sustainable soil health management through judicious use of micronutrients. This may help India enhance agricultural productivity, strengthen food security, and improve farmers' incomes, all while promoting sustainable agricultural practices. The time is ripe for action, and with the right policy interventions, India can set a benchmark for addressing micronutrient challenges and securing a prosperous future for the agriculture sector.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Deloitte.